no continuous absorption in the violet or ultra-violet, and the spectrum is one with simple line absorption, the iron lines quite disappearing after such a star as α Cygni is passed. The new lines which now make their appearance include the chromospheric line at λ 4471, and possibly a few others. It is important to note that the photographic region of the spectrum of the chromosphere has not yet been fully investigated, and hence a fair comparison with the spectra of these stars in the region F to K is not yet possible. M. Deslandres and Prof. Hale have photographed the chromospheric spectrum in the region more refrangible than H, but have not as yet published any account of the spectrum in the region now under discussion.

The Hottest Stars.

The conditions required by the hypothesis with regard to the stars at this stage are satisfied by such stars as ζ Cassiopeiæ and α Andromedæ.

In these stars we have—

(*a*) Broad lines of hydrogen, and

(*b*) Other absorption lines, chiefly of untraced origins, agreeing in position with some of the bright lines which appear in nebulæ.

It will be seen, then, that these considerations of the conditions of increasing temperature demanded by the hypothesis, have enabled us to determine that a long series of stellar spectra is in all probability a series in *ascending* order of temperature. All the phenomena we should expect, on the hypothesis, are met with among the photographs.

We have next to consider the phenomena connected with stars of decreasing temperature.

Stars of Decreasing Temperature.

(Stage 1.) With the failure of the supply of meteorites falling into the now vapourised mass, cooling will commence, and the longest lines in the spectra of the various chemical elements should make their appearance. This condition is met with and is well evidenced by the iron lines in the spectrum of Sirius.

(Stage 2.) The conditions at this stage of cooling are satisfied by δ Cassiopeiæ, β Cassiopeiæ, α Canis Minoris. In these stars we get, in addition to fairly broad lines of hydrogen, nearly all the lines which appear in the solar spectrum, and these, it is well known, agree in the main with the arc spectra of the various chemical elements.

(Stage 3.) Such stars as Capella and Arcturus represent the conditions which are required by the hypothesis at this stage of cooling. The metallic line absorption is again at a maximum, and we find the lines of the various chemical elements similar to those seen at Stage 2 of the ascending series, but with different intensities and with different amounts of continuous absorption at the violet end of the spectrum. This difference, so far as the known lines are concerned, will be due to a different percentage composition of the absorbing mass of vapour.

Continuous absorption in the violet recommences at this stage. There is undoubted evidence of carbon in the solar spectrum, and in the spectrum of Arcturus—the only star which has yet been investigated with special reference to this point.

Hence, it seems probable that "the indications of carbon will go on increasing in intensity slowly, until a stage is reached, when, owing to the reduction of temperature of the most effective absorbing layer, the chief absorption will be that of carbon."

It is evident that all such stars will be dim, and hence their spectra have not been met with in this preliminary survey of the photographic spectra of the brighter stars.

General Results of the Discussion.

The general result of the above discussion then, as far as it goes, is as follows:—Among the 171 stars already considered there are really two series of spectra, one representing the changes accompanying increase of temperature, while the other represents the effects of decreasing temperature. The fundamental requirement of the meteoritic hypothesis is, therefore, fully justified by the discussion of the photographs.

A very important point in connection with the two series of successive spectra is that one spectrum, such as that of α Andromedæ, possesses characteristics common to both, and we might, therefore, connect the two series together by this spectrum. In that case we should find, if we commence with the first spectrum in Series 1, say that of α Herculis, that the continuous absorption diminishes and that the breadth of the hydrogen lines regularly increases, until such a spectrum as that of α Andromedæ is reached. Then the condition would be reversed, the breadth of the hydrogen lines diminishing and the continuous absorption in the ultra-violet increasing in extent until such a star as Arcturus is reached.

It may be stated finally that the sequence now determined from the photographs follows exactly the same order as the groups originally suggested by the hypothesis, from a discussion of the eye observations. That is, it is not necessary to interchange any of the groups in order to obtain agreement with the photographic results.

J. Norman Lockyer.

SCIENCE IN THE MAGAZINES.

PROFS. WEISMANN, Haeckel, and Karl Pearson will probably have something to say in reply to a paper which Dr. St. George Mivart contributes to the *Fortnightly*. The paper deals with what is described as "Denominational Science," in which dogma takes the place of facts, and persuasions are given out as if they were demonstrated truths. Dr. Weismann comes under Dr. St. George Mivart's displeasure in this regard; and a noteworthy characteristic of his is said to be "the confidence with which he propounds hypotheses which are either purely imaginary, or are only supported by an infinitesimal basis of fact, and the readiness with which he comes forward with a fresh gratuitous hypothesis, to replace others which have been refuted by newly-discovered truths." Prof. Haeckel is taken to task for the opinions expressed in his book on "Monism," lately translated into English. The bearing of Dr. St. George Mivart towards the book is indicated by the remark which opens the attack upon some of the points in it. We read: "It is difficult to say whether this small volume is more remarkable for the self-conceit and empty dogmatism, or for the ignorance it displays—ignorance concerning the most fundamental questions of which its treats." To assess these remarks at their proper value, it is necessary to read the article containing them, and the work to which they refer. Prof. Karl Pearson completes the trio upon whose views Dr. St. George Mivart outpours the vials of his wrath. His "Grammar of Science," and his remarks, in the *Fortnightly*, on Lord Salisbury's Oxford address, are given as evidence that "we have in England a denominational writer only second in self-confident dogmatism to Haeckel." All the members of the trio are held up as awful examples of "an unconscious slavery of the intellect to the mere faculty of the imaginal tion, and the consequent presentation of shallow and illogical imaginary phantasms as deep and far-reaching intellectual truths in the form of baseless dogmas of denominational science." Huxley and Karl Vogt are compared by Prof. Haeckel in the *Fortnightly*, the former being given a higher place than the latter, both as regards his philosophical reasonings, and because he showed a much deeper insight into the essence and import of scientific things. Two pages of the six, which form Prof. Haeckel's notice, are taken up with a denunciation of Prof. Virchow's antagonism to Darwinism, and the theory of descent, especially with reference to the most important deduction from the theory—the descent of man from the ape. Virchow's dissent in this matter is used as one of the sticks with which Mr. F. H. Hill belabours agnosticism, and Huxley's support of it, in the *National*, under the title, "Gaps in Agnostic Evolution."

Mr. Herbert Spencer continues his analysis of "Professional Institutions," in the *Contemporary*, the evolution of the biographer, historian, and man of letters being traced this month. "The primitive orator, poet, and musician," says Mr. Spencer, "was at the same time the primitive biographer, historian, and man of letters. The hero's deeds constituted the common subject-matter; and taking this or that form, the celebration of them became, now the oration, now the song, now the recited poem, now that personal history which constitutes a biography, now that larger history which associates the doings of one with the doings of many, and now that variously-developed comment on men's doings, and the course of things which constitute literature." Thus arose the rudiments of biography, history, and literature; and many facts illustrative of this early development are cited. Fiction developed out of biography and history, and gradually a class of story-tellers became differentiated. Indeed, for a time after fiction comes into existence, it is still classed and believed as biography. In our own times, we find

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writers of history and biography and literature dividing into various classes, and finally there is the tendency of men of letters to unite into corporate bodies—an integration which has only become possible in recent years. In the same magazine, under the title "Heredity Once More," Dr. Weismann replies at length to an article contributed by Mr. Spencer to the magazine last October.

Mrs. Percy Frankland writes popularly on "Sunshine and Life," in *Longman's Magazine*, which also contains an account, by Mrs. A. Lang, of the Rev. John Mulso and his unpublished letters to Gilbert White, of Selborne, whose *alter ego* he was. Miss A. Lorrain Smith describes "Ants as Mushroom Growers" in an illustrated article in *Good Words;* her paper deals with the leaf-cutting and fungus-growing ants of Nicaragua. The *Sunday Magazine* has a second paper by "Eha," on Indian jungle life. *Knowledge* contains an account of Prof. Petrie's conclusions with regard to a "Newly-found Race in Egypt"; and papers on "Wind-Fertilised Flowers," by the Rev. A. S. Wilson; "Satellite Evolution," by Miss A. M. Clerke; "Photographs of Elliptical and Spiral Nebulæ" (with a plate), by Dr. J. Roberts; and "Blind Cave-Animals," by Mr. R. Lydekker. *Chambers's Journal* contains short popular articles on "Cordite and its Manufacture," and "The Prospects of our Descendants in regard to Stature," and a gossip on the Great Auk.

We have received, in addition to the periodicals named in the foregoing, *Scribner's Magazine*, and the *Humanitarian.*

ON THE ELECTROLYSIS OF GASES.[1]

IN the experiments described in this paper I have used the spectroscope to detect the decomposition of gases by the electric discharge and the movement of the ions in opposite directions along the discharge-tube.

The method consists in sending the electric discharge through a tube so arranged that the spectra close to the positive and negative electrodes can easily be compared, the presence or absence of certain ions at these electrodes can thus be ascertained. This method is capable of much wider application than the one I previously used in my experiments on the "Electrolysis of Steam" (*Proc. Roy. Soc.*, vol. lii. p. 90), the use of which is attended with very great difficulty for any substance other than steam. The earlier method has, however, the advantage of being a quantitative method—the present one is only qualitative.

In my former experiment with steam, when I worked at atmospheric pressure and varied the length of the spark, I found that when the spark-length exceeded a certain length, d_1, there was an excess of hydrogen at the negative electrode and of oxygen at the positive, equal in amount to the quantities of hydrogen and oxygen liberated from a water voltameter placed in series with the steam-tube. When the sparks were shorter than a certain length, d_2, the hydrogen appeared at the *positive*, the oxygen at the *negative* electrode, but the quantity of these gases was again equal to the quantities liberated in a water voltameter placed in series with the steam-tube.

When the spark-length was between d_1 and d_2 the effects were irregular, and there seemed to be no connection between the amounts of gases liberated in the steam-tubes and those liberated in the voltameter.

In the following experiments in which the sparks were of constant length and the pressure was altered, corresponding effects were observed. Within certain limits of pressure definite and perfectly regular evidence of the separation of the ions of the gas sparked through was obtained; and the electrode at which a given ion appeared could be reversed by altering the pressure; there was, however, a range of pressures in which the separation of the ions was either not well marked or was irregular in character.

I shall begin by describing a very simple method of showing the separation of the ions produced by the discharge of electricity through a compound gas such as hydrochloric acid gas, which is applicable when the discharges through the constituent gases of the compound are of distinct and different colours; this is eminently the case with the hydrochloric acid gas, as the discharge through hydrogen in a capillary tube is red, through chlorine green.

Take a capillary tube of very fine bore, the finer the better (the tube I used was thermometer tubing of the finest bore I could procure), and insert platinum wires for electrodes in two small bulbs blown on the ends of the tube; then fill the tube with HCl gas, allowing it to run through the tube for a considerable time so as to get rid of any extraneous gas, and exhaust the tube so that the gas in it is at a very low pressure. Then when the discharge from a large induction coil passes through the tube, the following phenomena are observed. When first the discharge passes through the tube the colour is uniform throughout and of a greenish-grey; after the discharge has been passing for a little time the end of the tube next the cathode gets distinctly red, whilst that next the anode gets green; this difference in the colour at the ends of the tube goes on increasing until the tube presents a most striking appearance, the part near the cathode being bright red, while that near the anode is a bright green. The difference in colour attains a maximum value, and if the discharge is allowed to run for several hours the contrast between the two ends disappears to a very great extent; the discharge throughout the whole of the tube being pinkish and apparently passing mainly through hydrogen. This is doubtless due to the diffusion through the tube of the hydrogen which in the earlier stages of the discharge had accumulated about the cathode; one advantage of using very narrow tubes is that with them this diffusion is slow. When the tube is in this condition the colour of the discharge sometimes changes suddenly, and for a second or two is green instead of pink, showing that though in the main the discharge passes through hydrogen, it occasionally leaves the hydrogen and passes through the chlorine. This transference of the discharge from one constituent to another of a mixture of gases is not infrequently observed when the gases are mixed in certain proportions.

Some of these capillary tubes showed after the discharge had been passing through them for some time a peculiar patchy appearance, some portions of the tube being a much brighter red than the others, while other portions were green. In some tubes this occurred to such an extent that the discharge showed an irregularly striated appearance. This effect is due, I believe, to gases or moisture condensed on the walls of the capillary tube, and in some cases to irregularities in the chemical composition of the glass. I found that it did not occur if the tube before being used was heated for some time along its whole length to as high a temperature as it would stand without collapsing; this heating would tend to cleanse the walls of the tube. That differences in the quality of the gas also conspire to produce these patches is shown, I think, by the following phenomenon. A capillary tube of fine bore containing mercury vapour and a little water vapour developed a well-marked red patch; the tube was then heated for some inches in the neighbourhood of the patch. In general heating the tube makes the discharge yellow from the sodium vapour given off from the glass; in this case, however, the whole of the heated portion, with the exception of the patch, turned yellow; the patch itself withstood the heating and continued to show the bright colour characteristic of hydrogen.

Electrolytic Transport of one Gas through another.—A tube of the shape shown in Fig. 1 was made of the finest bore thermometer-tubing; the extremities, C and D, of the tube in which the electrodes were fused were bent down so as to be parallel to each other, and so near together that a slight motion of the tube suffices to bring either of the extremities in front of the slit of the spectroscope. The tube was mounted on a board moved by a lever; by moving this the observer at the spectroscope could readily bring the spectrum of either the positive or negative electrode into the field of view. A side tube, A B, was fused to the middle of the main tube and was provided with two taps; in the space between these taps a small quantity of any gas which it was desired to introduce into the main tube could be imprisoned, and could, by opening the tap A, be introduced into the discharge tube. The experiment consists in filling the main tube with a gas at a low pressure, observing the spectra at the

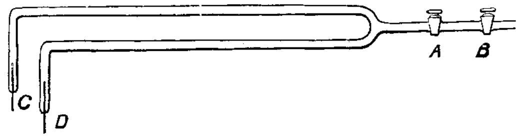

FIG. 1.

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[1] Paper read at the Royal Society, by J. J. Thomson, M.A., F.R.S., Cavendish Professor of Experimental Physics, Cambridge.

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